

August 24, 2022

## BOSTON TRANSPORTATION DEPARTMENT

### Fiber Optic Interconnect System Specifications

#### 1.0 General

This specification covers the requirements for multiple fiber optic cables suitable for installation in metropolitan underground ducts, cable trays, open air and subway systems. The cables described in this document consist of the loose tube design with fiber counts ranging from 6 to 144. The core of the cable is encased in an overall flame retardant jacket exhibiting low smoke, low halogen emission, and low toxicity properties when exposed to severe heat or flames.

The use of a flame retardant halogen free jacketing system allows one cable type to be used both for outdoor applications as well as in enclosed spaces where safety of personnel in the event of a fire is of concern.

In addition to the fiberoptic cable, a one inch diameter protective carrier shall be installed as part of this installation. See section 7.0.

#### 2.0 Optical Fiber

The single mode optical fibers shall meet the following specifications:

Mode Field Diameter	9.0 ± 0.5 μm @ 1.31 μm
Cladding Diameter	125 ± 1 μm
Core Eccentricity	≤ 0.8 μm
Fiber Non Circularity	<1.0%
Coating Outside Diameter	245 ± 10 μm
Nominal Zero Dispersion Wave Length	1.31 μm
Nominal Zero Dispersion Slope	0.086 ps/nm <sup>2</sup> ·Km
Attenuation @ 1.31 μm	≤ 0.4 dB/Km
@ 1.55 μm	≤ 0.3 dB/Km
Proof Test	100,000 psi

### 3.0 Optical Cable

3.1 Buffer Tubers - The optical cable shall be the loose tube, gel filled design with up to twelve color coded fibers contained within loose tubes filled with waterblocking gel. The loose buffer tubes shall be made of an abrasion resistant material while the buffer tube filling shall be a homogeneous hydrocarbon based gel, dermatological safe, non toxic, non nutritive to fungus, non hygroscopic, and electrically non conductive.

3.2 Color Code - The individual fibers in each buffer tube, and each buffer tube in the cable shall be color coded per the following sequence:

1. Blue	4. Brown	7. Red	10. Violet
2. Orange	5. Slate	8. Black	11. Pink
3. Green	6. White	9. Yellow	12. Aqua

The optical fibers shall be color coded using UV curable inks exclusively.

3.3 Cabling - The buffer tubes shall be cabled around a central member using either the helical stranding or reverse oscillation method. Fillers may be used to maintain the cable roundness. The interstices between the tubes shall be filled with a water blocking gel.

3.4 Fillers - Fillers shall be solid polyethylene rods of the same diameter as the fiber tubes.

3.5 Central Member - The central member which serves the function of anti-buckling element shall be a glass reinforced plastic rod with similar coefficient of expansion as the optical fiber. The central member may be coated with a layer of medium density polyethylene to achieve the required diameter.

3.6 Tensile Strength Member - Several strands of aramid yarn shall be applied over the cabled core in a counter-helical fashion to provide the desired tensile strength.

3.7 Rip Cord - A rip cord of a different color code than the aramid yarn strength members shall be pulled in longitudinally under the outer jacket.

3.8 Outer Jacket - A black outer jacket of a low smoke, low toxicity, halogen free polyolefin based compound shall be extruded over the entire cable core. The jacket shall contain carbon black to provide UV light resistance and shall not promote the growth of fungus. The nominal jacket wall thickness shall be 0.060 inches.

3.9 Cable Print - The outer jacket shall be marked with the following information:

- Cable Manufacturer
- Number of Fibers (24 fibers shall be supplied unless otherwise indicated on plans or in project specifications)
- Fiber Type (Single mode)
- Halogen Free, Low Smoke
- Date Coded (WWYY)
- Sequential Meter Marking Every Meter

The marking shall consist of orange colored block letters at least .25 inch in height and shall be indented into the outer jacket. The date code and sequential meter marking shall be white.

3.10 Cable Construction - Cables shall be constructed per the following guidelines.

No. Fibers	Fibers X Tubes	No. Tubes	Tube O.D.	No. Fillers	Nom. Cable O.D.
6	6	1	0.087 in.	5	0.395 in.
12	6	2	0.087 in.	4	0.395 in.
24	6	4	0.087 in.	2	0.395 in.

#### 4.0 General Performance Requirements

- 4.1 The cables shall be tested to insure compliance to the environmental and mechanical requirements per the appropriate EIA-455 document.

Characteristics	Requirements	EIA Document
Tensile Load (Installation)	2700N (608 lbs.)	EIA-455-33A,II
Tensile Load (Long Term)	600N (135 lbs.)	EIA-455-33A,II
Minimum Bend Radius (Installation)	15 X Cable O.D.	EIA-455-37
Minimum Bend Radius (Long Term)	10 X Cable O.D.	EIA-455-37
Water Penetration	No Penetration & Flow	EIA-455-82A
Compound Flow	No Flow	EIA-455-25A
Crush	220N/cm	EIA-455-25A
Compressive Loading Resistance	3mm to 20mm/Min.,10 minutes	EIA-455-41
Cyclic Flexing	25 Cycles	EIA-455-104
Impact	25 Cycles	EIA-455-25
Operating Temperature	-40°C to +85°C	EIA-455-3A
Storage Temperature	-40°C to +85°C	EIA-455-96

- 4.2 The maximum allowed increase in attenuation for each fiber in the cable before, during and after exposure to the environmental and mechanical tests shall be:

$$\begin{aligned} \text{Single Mode @ } 1.31 \mu\text{m} &\leq 0.4 \text{ dB/ Km} \\ &\text{@ } 1.55 \mu\text{m} \leq 0.3 \text{ dB/ Km} \end{aligned}$$

- 4.3 The low smoke, low toxicity jacket shall meet the following requirements:

Characteristics	Requirements	Test Method
Tensile Strength	900N/cm <sup>2</sup> Min.	FED-STD-228, M3021
Elongation	160% Min.	FED-STD-228, M3031
Tear Strength	45N/cm Min.	FED-STD-228, M3111
Scrape Resistance	250 Cycles Min.	MIL-C-85045E 4.7.4.16
Acid Gas	2% By Weight Max.	MIL-C-85045E 4.8.1
Halogen Content	0.2% Max.	MIL-C-85045E 4.8.2
Toxicity Index	5.0 Max.	NES 713
Smoke Generation		ASTM-E-662
Flaming	75 Max.	
Non Flaming	200 Max.	
Weathering	75% T&E Retention	MIL-C-85045E 4.7.5.8

- 4.4 The outer jacket shall be capable of being exposed to the following fluids for the specified duration of time. After exposure to these fluids, the outer jacket shall retain a minimum of 50% of the original Tensile Strength and Elongation values.

Fluid	Specification	Test Temperature	Duration
Fuel Oil	MIL-F-16884	33-37°C	24 Hours
Isopropyl Alcohol	TT-I-735	20-25°C	24 Hours
Lubricating Oil	MIL-L-17331 MIL-L-23699	73-77°C	24 Hours
Coolant	MONSANTO Coolanol 25 or equiv.	20-25°C	24 Hours
Seawater	ASTM-D-1141	20-25°C	24 Hours

- 4.5 Flammability - The entire cable shall pass the IEEE-383, 1974 vertical tray flame test.

## 5.0 Quality Assurance Provisions

- 5.1 First Shipment - Documentation demonstrating compliance to the requirements of sections 4.2, 4.3 and 4.4 shall be provided prior to release of the first order placed with a new manufacturer. Actual test data of tests performed on the same jacketing compound used, showing compliance to sections 4.3, 4.4 and 4.5 must be provided. Data obtained testing cables of a similar construction will be acceptable to demonstrate compliance to the requirements of section 4.2.
- 5.2 Subsequent Shipments - Documentation with a Certificate of Compliance to the requirements of sections 4.2, 4.3, 4.4 and 4.5 shall be provided once a manufacturer has met the conditions of section 5.1. In addition, Certified Test Data shall be provided with each shipment and attached to each reel with the following information:
- Attenuation measurements performed at 1.31 mm and 1.55  $\mu\text{m}$  (SM) for each fiber in the finished cable.
  - Other parameters listed in 2.0. Fiber manufacturer's data is acceptable.
  - Cable Outer Diameter
  - Outer jacket minimum and maximum wall thickness.

5.3 The manufacturer shall be ISO 9002 or ISO 9001 registered. Documentation providing the registration number received from an ISO Certified Registrar shall be supplied.

## **6.0 Packaging & Shipping**

Completed cables shall be packaged for shipment on non returnable wooden reels. The cable on reels shall be wrapped in a water resistant covering.

Each end of the cable shall be securely fastened to the reel and shall be capped to prevent the ingress of moisture. Six feet of cable length on each end of the cable shall be accessible for testing.

Certified Test Data shall be attached to the side of each reel.

## **7.0 One inch Diameter Protective Fiberoptic Cable Carrier**

Prior to installation of the fiberoptic cable, the contractor shall install a one(1) inch diameter protective fiberoptic cable carrier and pull rope within the conduit system where the fiberoptic cable is to be installed. The cost of this item shall be considered incidental to the installation of the fiberoptic cable and therefore no separate payment shall be made for this carrier.

## **8.0 Field Installation & Testing**

The contractor shall install the fiberoptic cable according to the cable manufacturer's recommended installation procedures. The fiberoptic cable shall be installed and terminated in every traffic control cabinet unless otherwise noted on project plans or in project specifications. No splicing of fiberoptic cables will be allowed. Each single mode fiber shall be fused to pigtails of factory installed LC connectors which shall in turn be connected to an approved wall mounted fiberoptic patch panel. All fibers including initially unused ones shall be terminated on a patch panel. The fiber patch panel and termination of the fiber shall be considered incidental to the fiberoptic cable bid item.

The contractor shall test the fiberoptic cable in the presence of the engineer as follows: a) using an optical TDR (time domain reflectometer). TDR readings must not include any unexpected discontinuities such as would be present if the fiberoptic cable was damaged during installation. The dB loss per kilometer shall be less than one(1) dB in order for the fiberoptic cable installation to be acceptable. b) using a Laser Light source at 1310 and 1550 nm and a power meter bidirectional tests should demonstrate readings consistent with the TDR readings adjusted for maximum connector loss of 0.5db and in line splice loss of 0.2db.

The contractor shall prepare a summary of test results which includes the following;

- 1) Limit of test area including which cabinet locations are included.
- 2) Results of power meter test for each strand at 1310 and at 1550 nm.

**9.0 Training**

A single 8 hour session of training shall be provided for fiber installations that exceed 1500'. The training shall include instruction relative to the installation, testing, and maintenance of the fiber system. Instruction and materials shall be provided for a maximum of 20 persons and shall be conducted at a time and location selected by BTD. The contractor shall submit proposed material to be covered for approval by the BTD Engineer.

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